

OPERATING INSTRUCTIONS

FOR

MILLIVAC

MODEL MV-18C

**SUCCESS OR FAILURE OF OPERATING AN INSTRUMENT SATISFACTORILY
OFTEN DEPENDS UPON WHETHER INSTRUCTIONS HAVE BEEN READ OR NOT.**



MILLIVAC INSTRUMENTS INC.

BOX 997, SCHENECTADY, N.Y.

OPERATING INSTRUCTIONS FOR THE
MILLIVAC TYPE MV - 18C
VACUUM TUBE MILLIVOLTMETER (RF)

IN ORDER TO AVOID MISUNDERSTANDINGS concerning the proper use of this unusual instrument, its calibration and its response to non-sinusoidal wave shapes a careful study of the following instructions is recommended.

Do not judge, nor re-calibrate this valuable instrument without first having read its instruction book in full detail. You will find it well worth your while.

OPERATING INSTRUCTIONS 11-99-A

Millivac Type MV-18C RF Voltmeter

General Information:

The MV-18C vacuum tube voltmeter by itself, without RF probes, is a highly sensitive millivoltmeter for DC. This instrument can be used for three basically different kinds of measurements:

a) DC Millivoltmeter: The right switch, marked "DC-mV" provides 3 measuring ranges, 10 mV, 2.5 mV and 1.0 mV full scale. Each range is being operated at MIDZERO, positive voltages reading to the right and negative voltages to the left. The right switch also acts as a general Function Switch. In its upright position marked, "Off", it disconnects the meter's power supply from the AC line. In its left position, marked "RF-mV, Use Left Switch" it connects the meter for RF voltage measurements as described below.

b) RF Voltmeter: As an RF voltmeter the MV-18C uses 3 types of germanium rectifier probes. They are probe A, AA and B. Their circuits are described in bulletin B-206 which is attached to this instruction book. Each probe contains a 1N34 crystal, a coupling and peaking condenser between the probe-tip and the crystal and a 1.5 megohm DC filter resistor. The probe converts the incoming RF voltage into a DC voltage which is fed into the MV-18C meter. The left switch on the panel of the MV-18C, marked "RF Volts", acts as a calibrated voltage divider, breaking down the DC voltage developed by the germanium crystal in such manner that definite calibrated RF measuring ranges are provided.

c) Thermocouple Meter: The MV-18C can be used for directly proportionate measurements of the RF input voltage of ordinary RF vacuum thermocouples and the new Pseudo-Thermocouples, manufactured by Millivac Instruments Corp. Such measurements can be carried out on the instruments 1 mV, 2.5 mV or 10 mV ranges by turning the right switch to the particular range desired and setting the meter's pointer to zero on the square law scale on top of the dial.

Accessories:

The MV-18C meter is furnished with a shielded probe-lead, a short 2-pole clip lead for DC measurements and our standard type A probe for RF measurements up to 2.5 V. The short DC clip-lead fits into the same female amphenol connector which holds the RF probe. In addition to the standard type A probe, which is supplied with each instrument, other probes are available on special order. Full details are given in our price list and bulletin B-206, attached to these instructions.

1) Operation of the MV-18C as a DC Millivoltmeter:

Plug shielded lead into input socket on panel and short clip lead into other end of shielded lead. Short input by clipping red clip to back clip. Set right switch to 10 mV range. Turn "Mid-Zero" (or UPSCALE ZERO) control clockwise until pointer reaches Mid-Zero position. Now open shorted input leads and connect to DC source whose voltage is measured. This source should have less than 100,000 ohms input impedance and should have less than 10% AC hum, otherwise mid-zero setting with shorted clips is incorrect with reference to actual DC voltage-measurement.

Switch on the meter's "Polarity Pulse" on the right side at the bottom of the panel. This pulse adds every second a small positive DC voltage to the voltage being measured. If the needle kicks to the right this means that the meter is not overloading and that the measurement is "right". If it kicks to the left it means that the meter is being overloaded by a negative input voltage and that the measurement is "wrong". After checking whether or not the meter is overloading turn off the polarity pulse.

If the meter is overloading (positively or negatively) on its 10 mV Mid-Zero range this indicates that the voltage to be measured is higher than 10 mV and therefore beyond the DC-reach of the instrument. On the other hand, if the reading is so small or so near to Mid-Zero that a larger deflection of the pointer is desired repeat measurements on the 2.5 and 1.0 mV scales. However, make sure that before each reading the pointer is reset to Mid-Zero by shorting the input terminals as described and adjusting the UPSCALE (or Mid-Zero) control.

The DC millivolt measuring ranges of the MV-18C are limited to measurements between approximately 100 microvolts and 10 mV. For higher voltages we recommend our MV-17C DC voltmeter which covers a total range between 100 microvolts and 1,000 volts, or the MV-27D which has a range of 25 microvolts to 1,000 volts.

NOTE: PREVENT MEASURING ERRORS BY REPEATEDLY SWITCHING ON THE POLARITY PULSE WHICH REVEALS NEGATIVE OVER-LOADING.

2) RF Millivolt and Volt Measurements:

Make sure that UPSCALE (or Mid-Zero) control is completely switched off. Also switch off Polarity Pulse. Select RF probe as follows:

For RF voltage measurements between 10 mV and 2.5 Volts plug type A probe into shielded lead.

For RF voltage measurements between 2.5 V and 1,000 Volts use B probe.

For RF voltage measurements between 100 mV and 25 Volts the AA probe is optional. It has a smaller input loading capacitance than the A probe and therefore is preferred against the A probe whenever minimum circuit loading is vital and extreme sensitivity not needed.

There is a dividing line between the 2.5V and 10 V ranges on the RF-Volts switch. On its left side use probes A and AA, on the right side probe B. Using the wrong probe or using



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the wrong side of the dividing line will give incorrect readings. To avoid burning out crystals, do not use probes above their rated values. In the event of crystal burnouts, return damaged probe to Millivac Instruments for repair.

3) RMS and Peak Measurements:

When making RF measurements with germanium crystal probes down to voltage levels as low as 10 mV or even less the user should bear in mind that below 100 mV these probes actually measure RMS values and above 1 V half-wave peak values. Between 100 mV and 1 V readings there is a transition from RMS to peak measurements. This difference between actual measurements does not influence readings if signal-waves are perfectly sinusoidal.

Millivac probes are calibrated with perfectly sinusoidal signal waves. Therefore any measurements of signal waves which are strictly sinusoidal will be correct over the whole range from 10 mV up beyond 1V. On the other hand, non-sinusoidal wave shapes may create considerable calibration discrepancies.

IMPORTANT:

WHEN MEASURING PURELY SINUSOIDAL VOLTAGES NO CONSIDERATION NEED BE GIVEN TO THE FACT THAT MILLIVAC PROBES (LIKE ALL CRYSTAL RECTIFIER PROBES) MEASURE RMS VALUES BELOW A CERTAIN VOLTAGE THRESHOLD AND PEAK VALUES ABOVE ANOTHER THRESHOLD, AS DESCRIBED.

4) RF-Scales:

The meter has 4 RF scales which are calibrated, as follows:

The top scale is used for all voltage ranges above 250 mV, except 10 V and 25 V. The next lower scale is used for 250 mV (probe A) and 25 V (probe B) only. The one below is calibrated for 100 mV (probe A) and 10 V (probe B) full scale. And the lowest scale is used for 25 mV Probe A only.

The attached bulletin B-206 contains all pertinent information with regard to RF frequency response and circuit loading features of the MV-18C meter.

5) Pseudo-Thermocouple Measurements:

Bulletin B-206, attached to this instruction book, also gives a detailed description of pseudo-thermocouples and their applications. It contains a typical calibration chart for such a PTC (Fig. 2).

The principal difference between probe measurements and PTC measurements lies in their calibration. While the MV-18C, when used with any of its probes, A, AA or B, is a regular calibrated high-frequency voltmeter, having 10 separate ranges between 25 mV and 1,000 V full scale, it is a basically non-calibrated RF galvanometer, when used with thermo-couples

of the regular heater type or with Millivac pseudo-thermocouples. For accurate measurements individual calibration of a given PTC at a given frequency with a given MV-18C meter is recommended. For less accurate measurements (within approximately 10% full scale accuracy) the calibration chart in Fig. 2 of B-206 may be used.

PTC millivolt-measurements may be carried out on the 1 mV, 2.5 mV and 10 mV DC ranges of the instrument, either at mid-zero or at square-law zero. After having plugged the PTC into the meter's shielded extension lead turn the UPSCALE or mid-zero control clock-wise until the needle reaches zero on either the square-law or the mid-zero scales. The PTC converts RF voltages, fed into it, into positive DC voltages which will drive the pointer upscale.

On the meter's 1 mV DC scale RF voltages as low as 1 mV can be observed. Approximately 10 mV will be found to drive the pointer to full scale on the square-law dial.

6) DC Calibration Check:

When checking the DC-calibration of the MV-18C proceed as follows:

- a) Switch meter to 1 mV DC range, short input terminals (black & red clips), switch off both up-scale zero control and polarity pulse and observe noise reading. It should be less than 10% of full scale. If it is higher this would indicate faulty tubes, a faulty power-supply or a noisy DC-modulator.
- b) Check 10 mV (mid-zero) calibration, using standard-cell potentiometer or equivalent. Source impedance must be less than 100 K.
- c) Check 2.5 mV (mid-zero) calibration in same manner.
- d) Check 1 mV (mid-zero) calibration.

7) RF-Calibration Check:

Before attempting to check the RF calibration of the MV-18C meter make sure that reliable RF calibration standards are available.

The average signal generator which is in commercial use today is a device which is designed to hold extremely high accuracy frequency-wise but has much less accuracy as far as wave shapes are concerned and a very poor accuracy indeed as far as voltage calibration is concerned. 80% of the MV-18C meters which we have supplied are used for the purpose of monitoring the output of signal generators.

The reason why signal-generator voltage calibrations are usually not very accurate and cannot be is this:

The voltmeter in a signal generator is usually electrically located at the end of a transmission line inside the generator while the output terminals are located at the end of another external transmission line (with or without pad). The output is further subjected to the calibration hazards created by the calibrated attenuator. To assume that the voltage calibration

at the end of a transmission line, following a hazardous divider and feeding the signal into a complex load, must be accurate, because the voltmeter on the panel of the signal generator gives a certain reading, would be about equivalent to the assumption that the voltage across the power plug of a refrigerator is correct because the voltmeter in the municipal power station reads what it should read.

The greatest hazard, however, is loading at the consumer's end of the signal generator's transmission line. A few uuf shunting capacity can upset calibrations considerably, often characteristic load impedances are not correct or have undergone changes and many other hazards are continuously threatening voltage calibration accuracy of a signal generator by itself.

After having shipped approximately 2,000 of these MV-18A, B or C Voltmeters, we have received approximately 15 complaints regarding calibration of these meters. In all these cases we have been able to track the complaint down to a misunderstanding on our customer's side of signal generator accuracy. We found that in all these cases the complaining customers had placed their full confidence in the voltage calibration of their signal generators and were surprised to hear that signal generators can be off in their voltage calibrations as much as 10, 20 and occasionally even 50%, as we have often verified it.

For further enlightenment on the subject of high-frequency voltage calibrations a reprint of a paper, "Conclusive Voltage Calibration of High Frequency Signals", is enclosed.

DO NOT MISJUDGE AND DO NOT SPOIL THE CALIBRATION OF A VALUABLE INSTRUMENT BEFORE BEING ABSOLUTELY SURE THAT THE STANDARD USED FOR COMPARISON IS RELIABLE AS FAR AS SINUSOIDAL WAVE-SHAPE, ACCURATE ATTENUATION, FREEDOM FROM TRANSMISSION LINE MISMATCHING ETC. IS CONCERNED.

8) Re-Calibrations, General Information:

Before attempting to re-calibrate the RF ranges of the MV-18C meter, its DC ranges should be checked and re-calibrated, if necessary. This procedure is of great importance because DC calibration directly influences RF calibration.

9) Re-Calibration of DC Ranges:

Follow the procedure outlined in chapter 6 which describes how to set up equipment for, and how to perform DC calibration checks.

In order to calibrate the DC ranges use the 3 amplifier gain controls in the back of the meter which individually adjust the gain on the 10 mV, 2.5 mV and 1 mV mid-zero ranges. When adjusting these controls it is always necessary to re-set mid-zero after which the effect of the re-setting upon calibration should be checked. The 3 d.c. calibration controls do not influence each other.

10) Re-Calibration of RF Ranges:

There is a calibration panel underneath the amplifier in the back of the meter. It contains 5 screw-driver-operated, properly marked potentiometers. They individually influence the calibration of the following RF ranges:

100 mV	(A Probe)
250 mV	(A Probe)
1 V	(A Probe)
2.5 V	(A Probe)
1 KV	(B Probe)

It will be noted that no individual controls are provided for the 2.5 mV, 10 V, 25 V, 100 V and 250 V ranges. The 25 mV range is automatically calibrated through proper calibration of the 10 mV DC range. If a minor correction should be found to be desirable, a compromise can be established by setting the 10 mV DC range either slightly higher or slightly lower to "split the difference" against minor calibration errors of the 25 mV RF range.

The 10 V range (B Probe only) is automatically calibrated by calibration of the 100 mV (A Probe) range. If these 2 ranges should not line up perfectly, the capacitive divider in the B probe should be adjusted so that the 10 V range matches the 100 mV range perfectly. In the same fashion, the 25 V range is automatically calibrated through calibration of the 250 mV range, the 100 V range through calibration of the 1 V range and the 250 V range through calibration of the 2.5 V range. Again it may be found desirable to strike a certain compromise setting of the capacitive divider in the B probe. This divider is screw-driver-operated and can be reached without opening the B probe.

The AA Probe should be used on all ranges which are designated for the A probe. Readings should be multiplied by 10 since the adjustable capacitive divider in the AA Probe has a ratio of 1:10. This divider should be reset only after perfect calibration of the A probe has been completed.

A, AA AND B PROBES ARE INDIVIDUALLY CALIBRATED FOR THEIR OWN METERS AND BEAR EACH METER'S SERIAL NUMBER. THEY CANNOT BE INTERCHANGED WITHOUT RE-CALIBRATION AND THEREFORE SHOULD NOT BE INTERCHANGED.

11) PTC-Calibration:

The pseudo-thermocouples, while originally intended to be used in uncalibrated fashion, can now also be used with an individual "calibration cord", type CL-112, available upon special order. This cord contains an adjustable potentiometer which makes it possible to calibrate accurately an individual pseudo-thermocouple so that the MV-18C reads exactly "100" on the square law dial when the RF input voltage is exactly 10 mV. This latest improvement, available upon special order only, now provides the possibility of operating a MV-18C meter with a perfectly calibrated 0-10 mV range.

12) RF Frequency Response:

Full information is contained in bulletin B-206 forming part of this instruction book (see figure 4). For highest accuracy at frequencies above 200 MC, individual calibration with a reliable signal source is recommended.

13) General Description of DC Meter Circuit:

The MV-18C uses a completely stable carrier-type DC amplifier which does not contain

bridge circuits and therefore, for all practical purposes, is free from zero drifts and the necessity of repeated zero adjustments. A "shunting contact" type DC modulator converts DC voltages into 120 cycles. The modulator should never be opened or tampered with since this automatically cancels the instrument's one-year guarantee.

A complete circuit diagram is attached.

The instrument has two range switches, the "RF VOLTS" switch and the "DC mV's" switch. The "RF volts" switch handles all ranges between 25 mV and 1000 V RF full scale. The remaining three lowest ranges (10 mV, 2.5 mV and 1 mV DC full scale) are handled by the "LOW-mV's" switch which feeds the incoming DC signal directly into the modulator but varies the carrier amplifier's gain. On the 10 mV range it is 20%, on the 2.5 mV range it is 40% and on the 1 mV range it is 100% of its maximum gain. All 3, the 10 mV, 2.5 mV and the 1 mV range are operated at mid-scale zero in order to "preload" the carrier amplifier's output rectifier. This lowers the instrument's minimum observable deflection" to less than 100 microvolts and makes it more valuable as a hypersensitive DC null detector and RF millivoltmeter.

The carrier amplifier used in this instrument has a so-called "starved" input tube (6J7) which operates at reduced plate current (0.02 mA) and has an exceptionally large load-resistor (16 meg.). This increases its gain to 1,000 or more. The second stage is directly coupled to the first. It is not starved and has a gain of 200, bringing the total gain of the first two stages to 200,000. The starved amplifier in this case amplifies the carrier signal produced by a DC modulator having less than 10 microvolts noise at 11 megohms input impedance. The negative feedback ratio on the most sensitive scale of this voltmeter is roughly 100 to 1, and on the less sensitive scales 1,000 to 1. With such high feedback rates, tube noise and hum are negligible.

The MV-18C measures positive and negative DC voltages in a forward direction. This eliminates the necessity of either switching leads or operating a reversing switch. However, the polarity of the voltage being measured can be determined by switching on the meter's "Polarity Pulse". This is a slowly beating neon-oscillator which every two seconds adds a small positive DC voltage in the measuring circuit. If the pointer periodically kicks to the right the polarity is plus, if it kicks to the left it is minus.

The meter has a 4" x 2" rectangular dial with 6 scales. They are the main scales covering all measuring ranges between 25 mV and 1000 V RF full scale, two special mid-zero scales for the 10 mV, 2.5 mV and 1 mV ranges, and a square-law scale. The latter is mainly for RF-RMS measurements with thermocouples. It facilitates conversion of DC readings into RF values. Its zero is raised to 20% of full scale in order to "preload" the output rectifier which makes the meter more sensitive at very low input voltages.

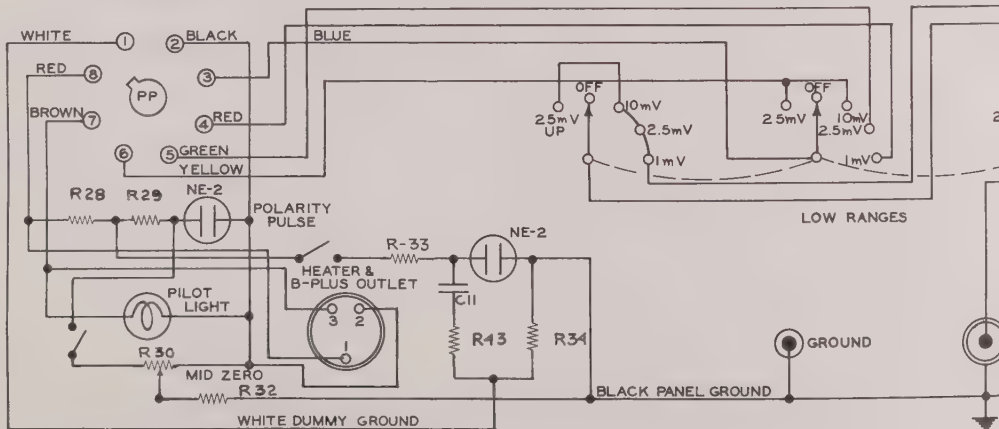
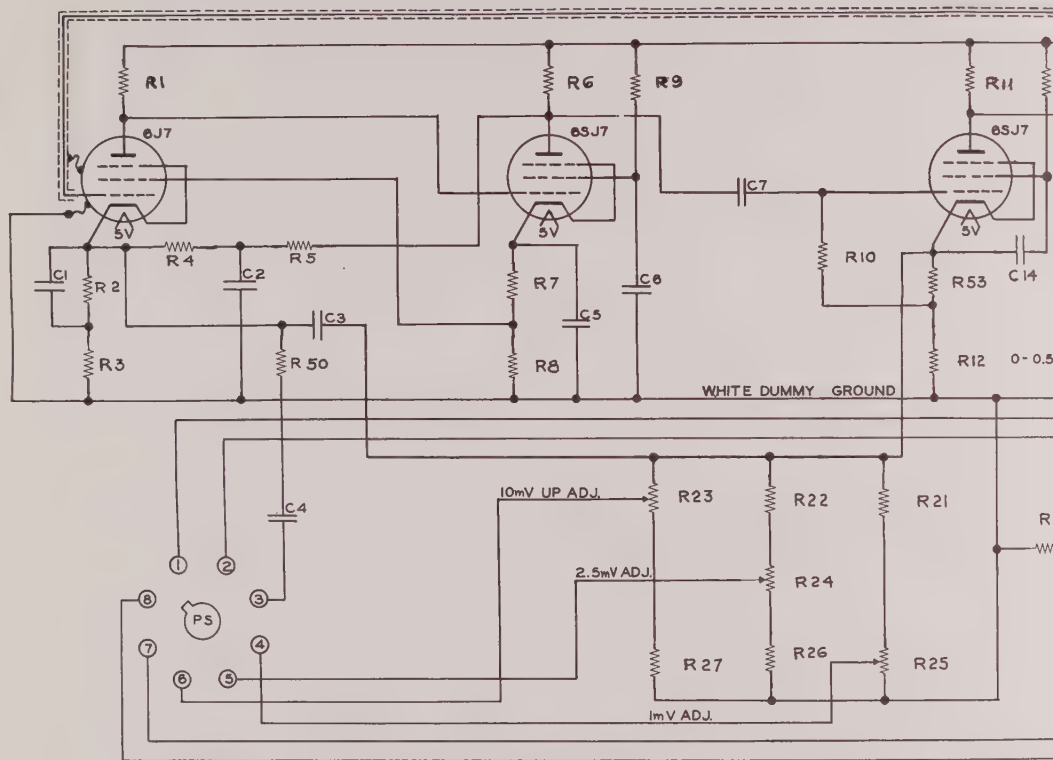
14) Guarantee:

The MV-18C (meter proper, without probes) is guaranteed for one year after date of shipment from the factory to customer against defective parts and workmanship. Do not, under any circumstances, return a meter, believed to be defective, to our factory without first taking the following steps:

1. READ THE FOREGOING INSTRUCTIONS CAREFULLY including bulletin B-206 in the back of the booklet.
2. MAKE SURE THAT THE UNUSUAL FEATURES OF THIS METER ARE FULLY UNDERSTOOD.
3. When making RF Volts measurements with probes make sure that the UPZERO or mid-zero control is completely turned off and that the polarity pulse is turned off.
4. When measuring small DC voltages make sure that the meter is not overloading by checking its performance with the Polarity Pulse, as explained above.
5. Check meter mechanically, for broken parts and dis-located modulator, due to transport shock.
6. Protect probes and pseudo-thermocouples against damage by excessive voltages. In many cases troubles can be traced to damaged probes. Keep a spare set of probes on hand for checking and reference purposes.
7. Recalibrate RF ranges when necessary.
8. Recalibrate DC ranges of meter only if you are sure that readings are more than 3% off. This will rarely be found to be the case.
9. DO NOT OPEN MODULATOR AS THIS AUTOMATICALLY CANCELS GUARANTEE.
10. If steps described above should fail to produce desired result write to us, care of SERVICE DEPARTMENT, describing exact trouble. Wait for authorization to send in meter. When sending it make sure to enclose exact return address and shipping instructions. All shipments must be prepaid.

MILLIVAC INSTRUMENTS
DIVISION OF COHU ELECTRONICS, INC.

Engineering Department

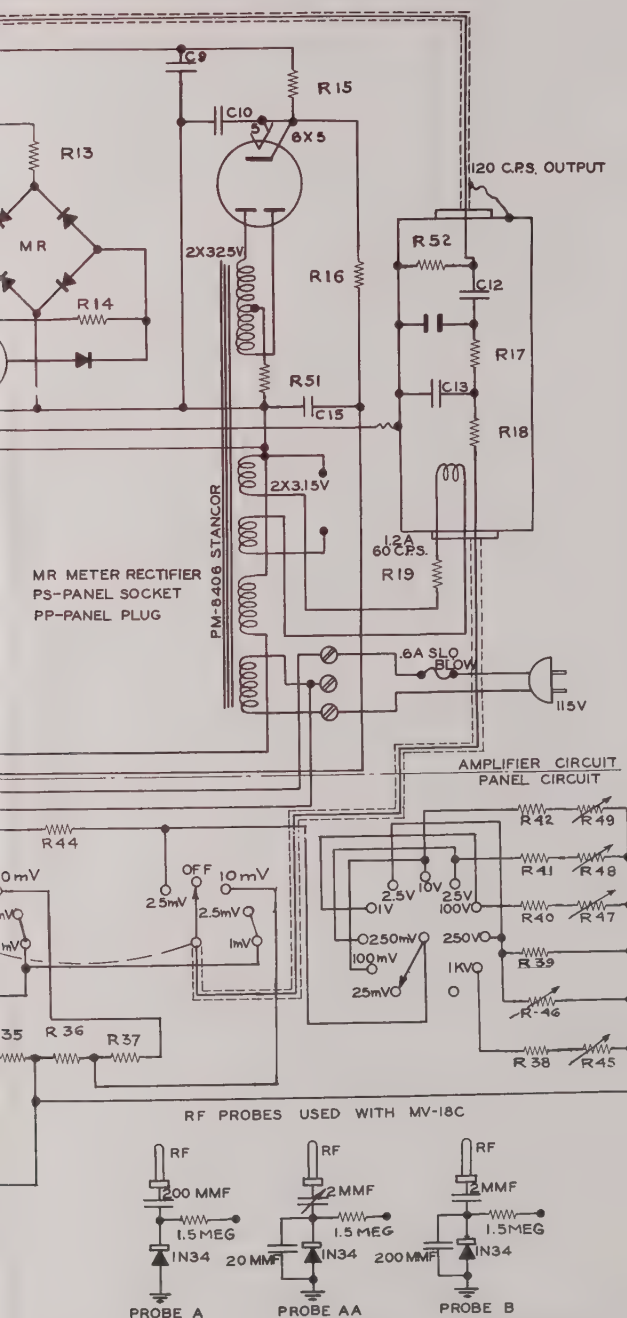


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MILLIVAC TYPE
MV-18C

MILLIVAC INSTRUMENT CORP.
444 SECOND ST.
SCHENECTADY NEW YORK



RESISTORS.

ALL 1/2 WATT UNLESS SPECIFIED

R1 4 x 3.9 MEG	R28 1.9 MEG. 1W
R2 43 K	R29 200 K
R3 130 Ω	R30 3 MEG. CT.
R4 4.7 MEG	
R5 4.7 MEG	R32 510 K
R6 390 K	R33 2 x 20 MEG
R7 15 K	R34 75 Ω
R8 51 K ADJ.	R35 15 MEG
R9 2 x 820 K	R36 4.5 MEG $\pm$ 1%
R10 1 MEG	R37 3.19 MEG $\pm$ 1%
R11 240 K	R38 510 Ω
R12 1 K	R39 24 K
R13 15 K	R40 8.2 K
R14 7.5 K ADJ.	R41 39 K
R15 24 K. 1W	R42 180 K
R16 1 K. 1W.	R43 30 K
R17 4.7 MEG.	R44 240 K
R18 1.1 MEG.	R45 1 K CONT.
R19 .47 Ω	R46 10 K CONT.
R20 7.5 K	R47 10 K CONT.
R21 130 K	R48 50 K CONT.
R22 56 K	R49 100 K CTR.
R23 50 K ADJ.	R50 7.5 K
R24 50 K ADJ.	R51 4.7 K. 1W
R25 50 K ADJ.	R52 18 MEG
R26 30 K	R53 1 K
R27 100 K	R54 2 x 620 K

CAPACITORS

C1 100 μ F 50V	C10 40 μ F 450V
C2 .05 μ F	C11 .1 μ F 600V
C3 .0005 μ F	C12 .01 μ F
C4 1 μ F	C13 .05 μ F
C5 8 μ F 250V	C14 .05 μ F
C6 .05 μ F	C15 20 μ F 450V
C7 .05 μ F	
C8 .5 μ F	
C9 40 μ F 450V	

DESCRIPTION:

The MV-18C is the first vacuum tube voltmeter for high-impedance millivolt measurements above 5 MC. Its design has been made possible by combining a carrier-type high-impedance DC vacuum-tube millivoltmeter (having 6 megohms input impedance and 1 mV full-scale deflection) with a new type of thermocouple, having substantially higher input impedance and higher sensitivity than the conventional vacuum thermocouple. This new "pseudo-thermocouple" is essentially a germanium rectifier diode operated at unconventionally low input-voltage levels (down to 1 mV). At these low levels the DC output-voltage of the germanium crystal is closely proportionate to the square of the RF input voltage in much the same manner in which the DC output of a vacuum thermocouple follows a square law. The MV-18C, at input voltage levels between 1 mV and 10 mV, is, therefore, a RF-thermocouple-meter of unusual sensitivity, excelling ordinary thermocouple meters by its high input impedance (50,000 to 150,000 ohms and 1 to 3 MMF compared to the 5 to 50 ohms heater resistance of vacuum thermocouples) as well as by its nearly flat frequency response up to 200 MC (heater loops and heater resonances being avoided). At these low voltage levels readings are taken on the 1 mV DC dial, a calibration chart (Fig. 2) being used for conversion of readings into RF millivolts. They may also be taken on the instrument's square-law dial which facilitates such conversion.

For RF voltage measurements above 10 millivolts and up to 1000 volts, 3 additional germanium diode probes are available which make it possible

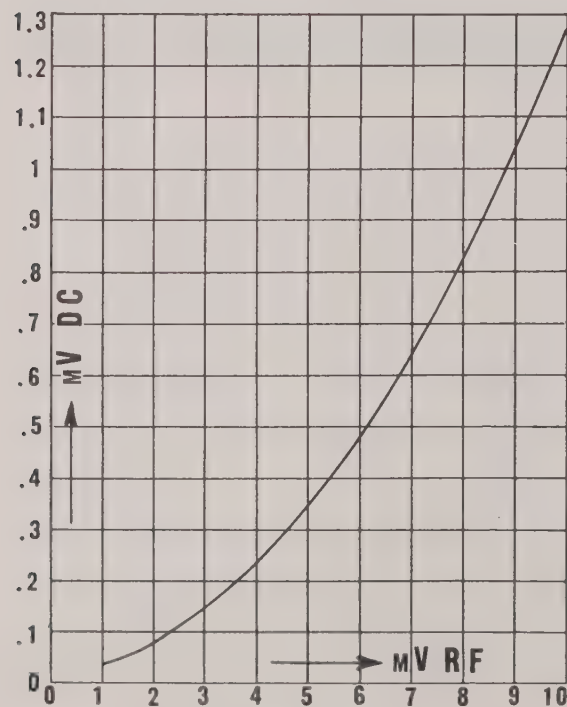


Fig 2
Pseudo - Thermocouple Calibration Chart

to read these voltages directly on the meter's 4 calibrated RF dials. Ten separate switch ranges are provided for this purpose, the lowest being 0-25 mV, the highest 0-1 kv.

MINIMUM CIRCUIT LOADING:

The MV-18C has 3 calibrated RF probes (types A, AA and B) having different capacitive input dividers and sensitivities. The circuits of these probes are shown in Fig. 3.

Probe A, in its latest "MINIMUM CAPACITY" form, has a rated input capacity of only 1.0 MMF plus-minus 25%. Such exceptionally low circuit loading was made possible by reducing crystal shielding to the very minimum and by housing both the RF and the DC filter components of the probe in a generously spaced polystyrene head. The probe is designed so that all conducting elements between tip and crystal, including the flat plates of the coupling condenser, are in a straight line. This keeps the probe free from resonance at high and ultra-high frequencies. The RF voltage leaves the probe as rectified DC through a 1.5 megohm filter resistor. The measuring range of this probe is 10 mV to 2.5 V.

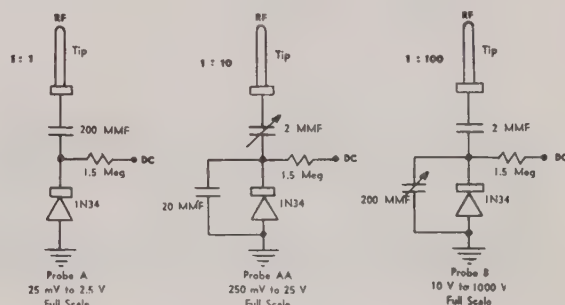


Fig 3 - Circuits of A, AA & B Probes

Probes AA and B are equipped with 1:10 and 1:100 capacitive voltage dividers. These two "extra" probes which are not supplied with the instrument unless specially ordered cover the RF voltage range between 2.5 volts and 1,000 volts. The input capacity of the AA probe is 1.5 MMF plus-minus 25%, its individual voltage range between 2.5 volts and 1,000 volts. A nameplate on the probe-shell states that readings are taken on the 25 mV to 2.5 V ranges of the meter and should be multiplied by 10. The B probe has 2.8 MMF rated input capacity, also with 25% tolerance. It covers voltages between 10 V and 1 kV and has its own meter ranges, no multiplication of readings being required.

RF FREQUENCY RESPONSE:

Fig. 4 shows the frequency response of the MV-18C when used with either a pseudo-thermocouple or any of its three-calibrated RF probes. The curve is completely flat up to 30 MC where it begins to decline, reaching—4% at 100 MC. At

200 MC it is 10% low, at 300 MC—15%, at 400 MC—20% and so on. Useful measurements have actually been carried out at 2,500 MC with a DC output only 30% of the output at 1 MC.

When using the meter with its 3 calibrated RF probes (type A, AA and B) accurate measurements at frequencies covered by this curve, can be taken by simply multiplying the readings with the percentage indicated by the curve for that particular frequency.

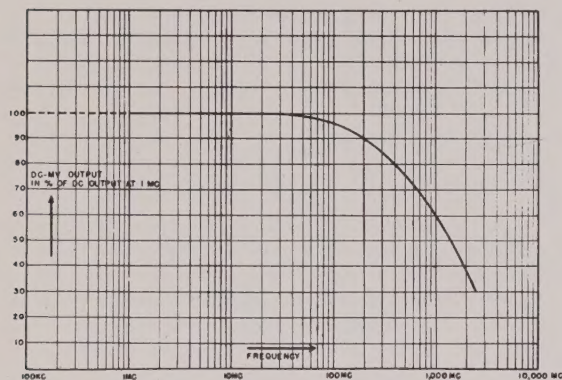


Fig. 4 - RF Frequency Response

When taking measurements with a pseudo-thermocouple the DC voltages measured are first converted into RF voltages by means of the DC vs. RF curve in figure 2. Then this value is multiplied with a frequency correction factor taken from figure 4.

DIAL:

The meter has a 4 1/4" x 2 1/4" rectangular dial with 6 scales. They are the DC mV scale with midzero for 1 mV, 2.5 mV and 10 mV full scale readings, 4 RF scales for all calibrated RF measurements between 10 mV and 1,000 V, and a square law dial for direct readings taken with pseudo-thermocouples. A MID-ZERO control is used for setting the instrument to zero on the square law scale as well as the DC mid-zero scales. This control adds a small adjustable DC voltage to the modulator's input circuit.

STABILITY AND TUBE NOISE:

The instrument has two range switches, the "RF Volts" switch and the "DC mV" switch. The "RF Volts" switch handles all "regular" RF ranges between 25 mV and 1000 V full scale by breaking down all incoming DC voltages to 10 mV full scale. The carrier amplifier's gain is then set for 10% maximum amplification. Stability, tube noise and modulator noise at this low level of amplification are transmitted to the output stage at such small amplitudes that the meter is completely stable, having less than 2% of full scale zero drift over many months of continuous operation.

The "DC mV" switch permits a step-by-step increase of the carrier amplifier's gain in order to

increase the meter's sensitivity. At the same time, tube noise and modulator noise are being transmitted to the output stage at increasing levels. To mask them at zero signal input and also to improve the instrument's "minimum observable deflection" both the 2.5 mV and 1 mV ranges are operated at midscale zero. This "preloads" the amplifier and its output rectifier stage, masking the latter's own contact potential. In spite of higher gains on the 1 mV and 2.5 mV ranges the meter is remarkably stable on these ranges, temporary drifts being less than 3% of full scale and long-time drifts usually remaining within 5-10%.

RF PREAMPLIFICATION:

The MV-18C is equipped with a special outlet carrying 6.3 V, 0.6 A — AC heater power and 250 V — DC for plate supply. This enables the user to connect simple single or double stage preamplifiers with germanium detectors to the instrument. In this manner, the meter's high input sensitivity may be further increased, if so desired.

PSEUDO-THERMOCOUPLES:

There are available several types of pseudo-thermocouples. They differ from each other by various input terminals and fittings. For frequencies above 50 MC the coaxial input type is recommended which eliminates local resonances caused by loops and make it easier to match input impedances. For lower frequencies, as well as for less accurate high frequency work, such as signal tracing in TV, FM and radar circuits, the handier type having a tip is recommended. Externally this type is identical with the calibrated A probe pictured in Fig. 1. Electrically it differs from this probe by having opposite crystal-polarity. It generates positive DC voltages whilst the 3 calibrated probes, according to common designing practice, are negative. Furthermore, pseudo-thermocouples, although they will stand substantially larger overloads than ordinary vacuum thermocouples, should not be exposed to the same high input voltages to which the 3 calibrated probes and their germanium crystals are currently being exposed (max. crystal voltage 10 V).

The ohmic leakage within the crystal is usually between 50,000 and 150,000 ohms. Therefore, the power drain, when measuring a single mV and assuming a crystal leakage of, for instance, 75,000 ohms would be 1.33×10^{-11} watts. To these losses should be added dielectric losses which vary with frequency. At any rate, the power drain caused by pseudo-thermocouples is many times lower than the consumption of heater type vacuum thermocouples.

POLARITY INDICATION:

The MV-18C when used as a DC millivolt meter, measures positive voltages to the right of its mid-zero position and negative voltages to the left. This eliminates the necessity of either switching leads or operating a reversing switch. The meter also has a "Polarity Pulse". This is a slowly beating neon-oscillator which every second adds a

small positive DC voltage in the measuring circuit. If the pointer periodically kicks to the right the polarity is plus, if it kicks left it is minus. In this manner unknown polarities of RF probes may be determined and negative overloading on the DC scales discovered.

CALIBRATION AND ACCURACIES:

The DC amplifier in this meter has 3 independent gain controls for the 1 mV, 2.5 mV and 10 mV DC ranges. After having set these as accurately as possible (DC accuracy of this meter is 3% of full scale) the following RF-probe calibrations can be performed:

The meter has an adjustable DC series filter resistor for accurate calibration of the type A-probe which is a standard accessory of the instrument. This control is adjusted for accurate full scale reading of the A-probe on the 2.5 Volt range after the instrument has been properly calibrated for DC as described. Further individual range controls make it possible then to individually calibrate the 250 mV, 100 mV and 25 mV ranges.

The AA-probe and the B-probe have their own adjustable capacitive dividers which are set and can be re-adjusted to give exactly 1:10 and 1:100 dividing ratios. This is done only after the meter

has been carefully calibrated on DC and after its A-probe has been properly calibrated.

The Pseudo-Thermocouples do not have any individual calibration but are calibrated for specific applications as follows: If only moderate accuracy but maximum convenience is desired signals can be read directly on the square law dial of the meter by interpreting its 0-100 divisions as 0-10 mV. The accuracy is usually within 10% of full scale. If higher accuracy is desired, direct calibration with a reliable signal generator before using each Pseudo-Thermocouple is recommended. Accuracy of 3% of full scale can then be obtained.

Some customers prefer our MV-181 AC calibrator which is a 60 cycle source with Output-Voltmeter and a calibrated divider. It feeds an accurately measured signal directly into the crystal of the Pseudo-Thermocouple through a large enough coupling condenser to eliminate errors by AC voltage drops. The accuracy of this method is in the order of 5% of full scale.

Our calibration methods were carefully developed to meet unusually severe requirements. They are described in a paper given by our Dr. W. K. Volkers before the National Electronic Conference in Chicago, 1953. A copy will be sent upon request.

APPENDIX: In order to facilitate voltage measurements with pseudo-thermocouples a new PTC-calibrating device has been added to the accessories which are available for the MV-18 C RF Millivoltmeter. This is the CL-112 PTC-calibrator - cord. It is a shielded probe lead containing an adjustable DC calibrator as well as a change-over switch. The DC calibrator is a potentiometer which makes it possible to adjust the sensitivity of the MV-18 C with a specific PTC plugged into the probe cord so that a 10 mV signal produces a full scale "100" reading on the square law scale, thereby calibrating

this scale with a particular PTC. For example, a 3 mV signal will then produce a "30" reading on the square law scale, etc. The change-over switch removes the DC calibration from the circuit and thereby makes the shielded lead a direct through-connection between a probe, plugged into it, and the MV-18 C meter. Therefore, when switching over to the direct connection, the probe lead may be used for regular measurements with A, AA and B probes. The CL-112 should be ordered separately since it is a special accessory.

SPECIFICATIONS

RF VOLTMETER RANGES:

0-25 mV, Probe A - 7% of full scale
0-100 mV, Probe A - 5% F.S.
0-250 mV, Probe A AA - 5% F.S.
0-1 V, Probe A, AA - 4% F.S.
0-2.5 V, Probe A, AA - 4% F.S.
0-10 V, Probe AA, B - 5% F.S.
0-25 V, Probe AA, B - 5% F.S.
0-100 V, Probe B - 4% F.S.
0-250 V, Probe B - 4% F.S.
0-1,000 V, Probe B - 4% F.S.

PROBE-RANGES AND INPUT CAPACITIES:

Probe A: 1.25 MMF, 25% tol.,
25 mV to 2.5 V full scale.
Probe AA: 1.5 MMF, 25% tol.,
250 mV to 25 V full scale.
Probe B: 2.8 MMF, 25% tol.,
10 V to 1000 V full scale.

Note: Unless specified differently the MV-18C will be supplied with one A-probe only. For different PTC-types see price list.

PSEUDO-THERMOCOUPLE METER RANGE:

0-10 mV only - for accuracies see above under "Calibration".

PTC-TYPES AND INPUT CAPACITIES:

PTC-1—Pseudo-Thermocouple—Similar to probe A but has reversed crystal polarity (positive DC output voltage), equipped with conventional probe-tip. 1.25 MMF input cap.
PTC-2—Identical with PTC-1, but has binding posts instead of tip. 5 MMF input cap.
PTC-3—Identical with PTC-1, but has coaxial connector, type PL-259, CHP-49190, made by American Phenolic Corp. 8 MMF input cap.

DC MILLIVOLTMETER RANGES:

0-1 mV, 6 megohms
0-2.5 mV, 6 megohms
0-10 mV, 6 megohms

Power Supply: 115 V, 60 cycles
Dimensions: Width 7"; Height 12"; Depth 6".

NOTE: For description of other Millivac AC-Voltmeters see our bulletin B-205.

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